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1 JUNE 2016
VOLUME 97, ISSUE 11

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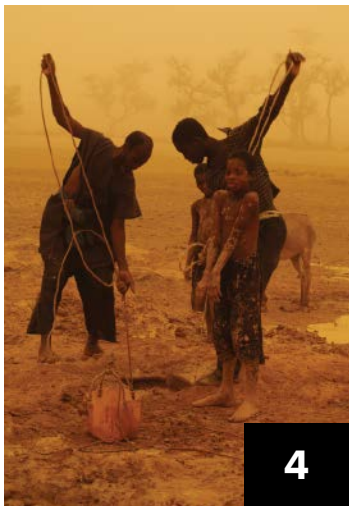

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Christine W. McEntee, Executive Director/CEO

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Senate Pushes USGS Director for More Action on Minerals, Hazards

Senate Photography

U.S. Geological Survey director Suzette Kimball testified at a 7 April Senate oversight hearing about the agency.

U.S. senators pressed the director of the U.S. Geological Survey (USGS) to beef up its minerals and hazards programs at a 7 April oversight hearing about the agency's priorities, budget, and cutting-edge science.

At the hearing, Sen. Lisa Murkowski (R-Alaska), chair of the Senate Committee on Energy and Natural Resources, called mineral security a USGS core area that lacks attention and resources.

"I remain seriously concerned about our growing foreign mineral dependence," she said. "Even though minerals are more important to our modern society than ever before, we are paying less and less attention to them." Murkowski said that less than 10% of the USGS budget goes to its minerals program and that it is difficult to find anyone in the federal government "who is responsible for doing anything to meaningfully reduce" the nation's dependence on imports.

Suzette Kimball, whom the Senate confirmed as USGS director last December, said that the agency recently launched its mineral work in "new strategic directions." The agency is enhancing its ability to conduct mineral life cycle analyses to better understand mineral resources from cradle to grave, which Kimball deemed "essential" as society uses new technologies that require different minerals. Also, last fall the agency brought on an associate director for mineral resources, she noted.

In an interview with *Eos* after the hearing, Kimball said that the agency is "looking not just to rebuild but to enhance both our capability and our capacity" in its minerals work. The agency's budget request for its Energy and Mineral Resources and Environmental Health area for fiscal year (FY) 2017 is $99.48 million, an increase of 5.3% above the FY 2016 enacted level. Overall, the agency has requested $1.169 billion, a 10% increase above FY 2016 (see http://bit.ly/2017-USGS).

Senators Call for More Work on Hazards

Senators also urged the agency to increase monitoring of volcanic and seismic activity, landslides, tsunamis, and other hazards. Ranking committee member Sen. Maria Cantwell (D-Wash.) called for strengthening those programs, noting that five volcanoes in her state pose high or very high risk, including Mount Rainier, which USGS considers the most threatening volcano in the Cascade Range.

Kimball testified that USGS has a "priority activity to begin looking at the Cascadia subduction zone. There is more to be done to understand the mechanics." She added that "perhaps a more important aspect is to make sure individuals understand the potential, understand the true probability of an event and what to do should that kind of event occur."

Providing Scientists with the Tools They Need

Kimball stressed to *Eos* that USGS has important mission priorities associated with natural hazards. She said, however, that warning systems for volcanoes and earthquakes and collecting lidar data needed to evaluate landslide potential "are all very expensive undertakings. And our current instrumentation has some age on it. We were given a leg up with the [2009 American Recovery and Reinvestment Act] funds several years ago, but in fact these are all the kinds of activities that really require new types and state-of-the-art" instrumentation.

She added that "for our scientists to do their work," they also require sensors, access to supercomputing capabilities, and well-eqipped laboratories, all of which "are not inexpensive." She said the agency has received inadequate funding for facilities maintenance, leading to damage to some "irreplaceable" data sets.

"If we look out 10 years, we have a growing [funding] backlog that does approach $400 million," Kimball noted. "We recognize this isn't on the same scale as, say, the facilities maintenance backlog with the [National] Park Service, but for USGS and the USGS budget it is a very, very significant problem."

A Focus on Innovation

Kimball said she most hopes to nurture innovation during her tenure as USGS director. "While the [agency] has often been at the forefront of innovative research and science, we must take advantage of technological change and respond to emerging scientific directions to meet our full potential," she said at the hearing.

The desired innovations, she said, can range from novel technologies—such as using DNA found in the environment, called "eDNA," to monitor the spread of invasive Asian carp—to researching how enriched algal injections into deep coal beds might jump-start bacterial action to extract a coal bed's energy without incurring environmental or public safety risks.

Right now is "the time to start thinking about what we need to do as scientists to be ready for the questions that somebody is going to be asking 20 to 30 years from now," she told *Eos*, "not 2 weeks from when they need the answer."

By **Randy Showstack,** Staff Writer

New Climate Studies Reveal Risks at 2°C Rise, Higher Rise Likely

Men and children withdrawing water for irrigation in the Dogon plateau (Mali) during a sandstorm. New research finds that warm spells in tropical regions will likely last 50% longer if warming exceeds the global preindustrial average temperature by 2°C rather than by 1.5°C

On Earth Day, 22 April, leaders from 175 countries plus the European Union gathered at the United Nations and signed the Paris climate agreement reached last December. Under the historic deal each country set targets to reduce greenhouse gas emissions, with the ultimate goal to keep the rise in global temperatures below 2°C above the preindustrial average (see http://bit.ly/paris-climate-2015).

However, new research presented at the 2016 European Geosciences Union (EGU) meeting in Vienna, Austria, the day before the signing shows big differences between a 2°C warmer world and a 1.5°C warmer world. The study suggests that the just-signed pact's emissions caps might not be low enough to prevent damaging impacts for parts of the world that are vulnerable to climate change.

The study, published on 21 April in *Earth System Dynamics,* shows that tropical regions would be especially hard hit by a 2°C temperature increase (see http://bit.ly/differential-climate-impacts). Warm spells would last up to 50% longer, resulting in corn and wheat yields half of what they would be under a 1.5°C increase, the researchers found. What's more, a 2°C temperature increase by 2100 would also mean that all coral reef ecosystems in tropical regions would be at risk of degradation due to coral bleaching, according to the study led by Carl Schleussner of Climate Analytics in Germany.

Greater Reductions Needed

To limit temperature increases to just 1.5°C, countries may need to strengthen their emissions reduction pledges significantly. Even if the current Paris commitments are met and extended beyond 2030, global temperatures are on track to rise 3°C above the preindustrial average, said Massachusetts Institute of Technology climate scientist Erwan Monier.

He collaborated in another study, also presented at the EGU meeting, that combined a human activity model with a climate model to look at five different global warming scenarios through 2100. His team found that there is only a 5% probability that the Paris agreement will keep global temperatures below 2°C, even with the most optimistic outlook (see http://bit.ly/MIT-globalchange).

Nonetheless, Monier told *Eos* that it is still possible to limit temperatures to 2°C by the end of the century. However, that would require major changes in policy. "We're not on that path right now, but it's totally achievable," he said. "I think most people know some policy tools that would get us there, like a carbon tax. But there's unwillingness to actually use those."

Possible 2.7°C Rise Scrutinized

Other researchers have focused on tipping points for severe climate impacts that may lie beyond 2°C. Climate scientist Robert DeConto of the University of Massachusetts Amherst published a paper in *Nature* in March that found that the Antarctic ice sheet would barely contribute to sea level rise if the average global temperature rise stayed below 2°C (see http://bit.ly/antarctic-sea-level).

Since writing that paper, DeConto has applied his same model to a temperature increase of 2.7°C. At a 21 April press conference at the EGU meeting, DeConto explained that his preliminary results suggest that the Antarctic ice sheet would contribute about 80 centimeters of potential sea level rise in a 2.7°C warmer world (see http://bit.ly/COP21-PC). DeConto chose to scrutinize the effects of a 2.7°C increase because the Climate Action Tracker had warned ahead of the Paris agreement that the world is headed for that level of warming by 2100 even if governments fully implement their climate action pledges (see http://bit.ly/still-above-2C).

Glacier Loss Will Continue Under Cuts

Highlighted also in the press conference, another study finds that regardless of the success of the Paris agreement, some damaging aspects of climate change can't be stopped. Glacier melt will continue to accelerate, explained Ben Marzeion, a climate scientist at the University of Bremen in Germany. He presented his results during an earlier session at the EGU meeting. If it were scientifically possible for global warming to stop today, glaciers would still lose 30% of their mass. Even a modest 1.5°C increase, according to Marzeion, would still result in about half of glaciers melting (see http://bit.ly/glacier-mass-change).

By **Megan Gannon,** Freelance Writer; email: megan.i.gannon@gmail.com

For a science-policy perspective on the Paris accord cuts, visit http://bit.ly/eos_moniz.

Arctic Sea Ice Extent May Shrink Below 2012 Record Low

Alfred-Wegener-Institut/Stefan Hendricks

Sea ice photographed in the central Arctic Ocean during summer 2015, when Arctic sea ice was exceptionally thin, according to satellite data.

Recent conditions in the Arctic suggest that by the end of this summer, the region's sea ice could shrink to—or even below—the record low observed in 2012, scientists announced at the 2016 European Geosciences Union (EGU) meeting in Vienna, Austria.

At a 21 April press conference the researchers discussed signs of impending ice loss that they had noticed while reviewing ice thickness maps from the past several years from the CryoSat-2 satellite (see http://bit.ly/Arctic-Sea-Ice).

"What was striking to us is that the ice thickness distribution in this spring, or at the end of winter, is very similar to 2012, which was the previous record minimum," said sea ice physicist Marcel Nicolaus of the Alfred Wegener Institute (AWI) Helmholtz Centre for Polar and Marine Research in Bremerhaven, Germany. The sea ice at that time extended over just 3.41 million square kilometers—roughly half the average annual minimum ice coverage between 1981 and 2010.

Multiple Factors Signal Sea Ice Shortage

In its evaluation and projection for 2016, the research team factored in the recent history of Arctic warming and regional ice loss and growth. The scientists also considered ice thickness measurements from 2015 and 2016 and expected ocean currents and winds.

In addition, measurements from a set of seven "snow buoys" contributed to the outlook. The researchers had affixed those sensor towers—which track snow thickness and air temperatures and pressures directly on the sea ice—to ice floes last fall.

Nicolaus and his colleagues developed the concept for using buoys to measure snow depth; they passed this concept to a Canadian company from which they now buy the devices. Each snow buoy consists of a base unit that's drilled into ice with a 1.5-meter mast topped by a rack of four sonic ranging sensors that autonomously transmit their data via Iridium satellites. Nicolaus said his colleagues joked that the buoy looks somewhat like a rack for hanging clothing.

> "If weather conditions turn out to be unfavorable, we might even be facing a new record low."

Balmy Winter Slowed Ice Growth

The potential replay of 2012 or worse stems in large measure from the exceptional warmth of the 2015–2016 winter, the researchers noted. Readings from the group's snow buoys in February showed that the central Arctic temperature in that month surpassed the average by up to 8°C, the team reported. Nonetheless, the extreme winter warmth didn't make ice melt away. "According to our buoy data from the spring, the warm winter air was not sufficient to melt the layer of snow covering the sea ice, let alone the ice itself," Nicolaus said.

"Only over the last decade has it became more and more obvious how important the snow cover is for sea ice," he told *Eos*. For instance, snow's high albedo and other physical properties, such as its ability to provide thermal insulation, can affect the way that sea ice forms and melts.

Instead of melting ice, high 2015–2016 winter temperatures significantly slowed the usual seasonal thickening of sea ice, the scientists explained to reporters. Ice extending from the land in areas north of Alaska, for instance, had attained just two thirds of its usual thickness, measuring 1 meter thick rather than 1.5 meters.

Prediction Challenge

Ice researchers have observed an overall decline in Arctic sea ice abundance ever since satellite records for such data became available in the 1970s. But year-to-year predictions for sea ice decline are difficult to make because the internal variability of sea ice thickness is quite large, said Alexandra Jahn, a climate scientist at the University of Colorado Boulder, who was not involved in the projections. Jahn compared the sea ice prediction challenge to making an accurate forecast today of the weather for this coming Christmas. "We have that inherent uncertainty in the system," she told reporters.

Weather Matters Most

Ultimately, the amount of sea ice present when its extent bottoms out at summer's end depends disproportionately on the patterns of wind and of air and water temperatures in the months just before the minimum is reached, Nicolaus and his colleagues explained. "The Transpolar Drift Stream, a well-known current in the Arctic Ocean, will be carrying the majority of the thick, perennial ice currently located off the northern coasts of Greenland and Canada through the Fram Strait to the North Atlantic. These thick floes will then be followed by thin ice," said sea ice physicist

Alfred-Wegener-Institut/ Stefan Hendricks

A snow buoy erected on Arctic sea ice near the coast of Alaska.

Stefan Hendricks, also of AWI. "If weather conditions turn out to be unfavorable, we might even be facing a new record low."

Julienne Stroeve, a senior research scientist with the U.S. National Snow and Ice Data Center (NSIDC) in Boulder, Colo., who wasn't involved in the AWI analysis, agreed. "We are preconditioned for a big melt year if the weather patterns favor melt," Stroeve told *Eos*. "Unfortunately, we cannot predict the weather, so it remains to be seen. However, if we have a relatively warm summer and a circulation pattern that promotes more ice flow out of Fram Strait, we certainly could be looking at a new record low this summer."

Ice-Free Arctic?

Other sea ice research presented at the EGU meeting took a look further ahead to times when the Arctic could see up to seven ice-free months each year if greenhouse gas emissions are not cut.

One effect of that diminished ice cover could be bigger waves in Arctic seas, according to Mikhail Dobrynin, an oceanographer at Universität Hamburg's Center for Earth System Research and Sustainability in Germany. Dobrynin presented a new model for wave patterns in the Arctic based on projections of wind and ice conditions (see http://bit.ly/ocean-waves-climate).

His simulation showed that with less ice and longer reaches of open water, winds can build waves to greater size and strength. In turn, those more powerful waves could break up the sea ice faster and further erode already fragile coastal areas in the region (see http://bit.ly/waves-vs-Arctic-ice).

By **Megan Gannon,** Freelance Writer; email: megan.i.gannon@gmail.com

Seeking Knowledge in the Dust

The Batsheva de Rothschild Seminar on Atmospheric Dust, Dust Deposits (Loess) and Soils in Deserts and Desert Fringe
Jerusalem and the Negev Desert, 14–19 October 2015

Onn Crouvi, GSI

Field trip participants examine quartz-rich coarse-silt sediments (grains with a mathematical mode of 90–100 micrometers) at the fringe of the northwestern Negev dune field. The adjacent, upwind sand dunes are the most likely source of these silty sediments, which lie on the carbonate bedrock that makes up most of the Negev.

Mineral dust's primary roles in forming soils, supplying nutrients to the oceans, and modifying regional climate and environment have been known and studied for decades. Terrestrial, marine, and lacustrine (lake) archives of dust provide information about processes and episodes of dust grain production, dust sources and transport, and climate.

The dust scientific community is traditionally divided into two main groups: Climatologists, atmospheric modelers, oceanographers, and geochemists mostly study atmospheric dust, which is composed of clay and fine-silt grains and transported across hundreds to thousands of kilometers. Geomorphologists, Quaternary geologists, and pedologists (soil scientists) study the entire range of dust grains but often focus on coarse dust—composed of medium- to coarse-silt grains, transported across limited distances, and commonly forming thick loessial deposits. Despite years of research on atmospheric dust and dust deposits, the interaction between and within these two groups is limited, and this hinders the advancement of knowledge and understanding about the dust cycle.

To bridge this gap, we brought together an interdisciplinary group of geologists, geomorphologists, pedologists, geochemists, archaeologists, modelers, and climate experts for a 5-day seminar and field trip (see http://bit.ly/Dust-seminar) to discuss recent advances and challenges in the disciplines of dust, dust deposits, and soil development in arid and semiarid regions. The seminar was part of the AEOMED project (Loess and Aeolian Additions to Current Surface Soils and Paleosols in Mediterranean Climate), under the International Union for Quaternary Research (INQUA) commission on Terrestrial Processes, Deposits, and History (TERPRO; see http://www.terpro.org.ar).

The field trip to the Negev desert offered diversity in dust deposits and climate over a very short distance of tens of kilometers. This diversity provides a "natural laboratory" for examining spatial and temporal variability in the processes responsible for loess deposition and soil formation in the past along a transect from the proximal source of the loess (sand dunes) to different sinks located downwind.

> We encourage climatologists and atmospheric scientists to become involved in field-based research.

Fifty-nine scientists from 10 different countries attended the seminar. Presentations over the course of 2 days addressed recent advances in our understanding of the following topics:

- dust generation and emission
- dust transport and deposition in and around the Mediterranean (North Africa and Europe)
- dust sources and deposits in the United States
- dust deposits and soils
- dust provenance
- loess in Italy's Po Plain and comparison to other Mediterranean regions

During the 3 days of the field trip, we visited key loess sequences in the core and edges of the Negev loess and discussed identification, chronology, characteristics, and sources of the desert's primary loess (the field trip guide book is available online at http://bit.ly/Dust-guidebook). We visited the fringe of the northwestern Negev dune field, where silt grains are generated from sand, and we visited well-dated, fluvially and colluvially reworked loess sequences documenting late Pleistocene fluvial activity (starting about 70,000 years ago). We examined prehistoric sites associated with aeolian (wind-borne) deposits, drove along the incense route and visited ancient Nabatean cities, observed the operation of a large portable wind tunnel, and visited exposures of lacustrine Dead Sea basin sediments partially composed of primary and secondary dust/loess.

The field trip stimulated discussions about the basic formation of silt grains in deserts, identification of loess and dust sources, transport of dust particles, and the accretion of dust deposits and formation of cumulic (accumulating) soils within them under different climatic regimes during the late Quaternary (mainly over the past 180,000 years). The group stressed the importance of interdisciplinary research and field experience to advancing our understanding of the dust cycle.

Following the learning experience of the diverse group of scientists participating in the field trip, we encourage climatologists and atmospheric scientists to become involved in field-based research. This involvement will help them acquire a sense of the quality of records involved and in turn will improve the interpretations of these records by Quaternary geologists.

By **Onn Crouvi** and **Rivka Amit,** Geological Survey of Israel, Jerusalem; email: crouvi@gsi.gov.il; and **Yehouda Enzel,** The Hebrew University of Jerusalem, Jerusalem, Israel

Gender Diversity in Cryosphere Science and Awards

Allen Pope

A member of the Juneau Icefield Research Program on British Columbia's Llewellyn Glacier.

The following question was raised during the February 2016 meeting of AGU's Cryosphere focus group Executive Committee: Do awards given by the focus group reflect the diversity in our field?

This deceptively straightforward question is hard to answer. Cryosphere awards are not balanced—there is less diversity in our more senior awards—but to what extent is imbalance expected given that women and minorities are underrepresented across science, technology, engineering, and math (STEM) fields [see *National Center for Science and Engineering Statistics,* 2015; *Blickenstaff,* 2005; *Williams et al.,* 2014]?

The Cryosphere Executive Committee's inability to answer its own question demonstrates that even where individuals are concerned about diversity, knowledge is lacking. If we value diversity and believe our discipline will be at its best when every student has equal opportunity, then we must do more than talk; we must act. Awareness and data collection are part of ensuring a diverse field now and in the future.

A Hot Topic in a Cold Field

In March 2016, diversity research within the cryosphere community was attacked, causing concern beyond ensuring a fair awards system. A message to Cryolist (http://cryolist.org), a major cryospheric sciences listserv, expressed the opinion that an advertised study of sexual harassment in Earth science was likely a "spoof" and not appropriate subject for study (see http://bit.ly/CryolistSHstudy). Yet a study on scientific fieldwork found that 64% of respondents experienced sexual harassment [*Clancy et al.,* 2014].

A paper by *Carey et al.* [2016], drawing attention to the gendered nature of cryosphere knowledge production and the lack of diversity in knowledge transfer, sparked a frenzy in the blogosphere and was criticized as being unserious and not worth the tax dollars spent on it (e.g., http://bit.ly/gawkrgenderglaciers).

Were these reactions aberrations or typical of the cryospheric science community? We cannot answer this question; however, we can say that AGU's Cryosphere Executive Committee is committed to diversity within our field and to quantitative assessment of demographic data.

Focus Group by the Numbers

AGU started tracking sex and age data for our group in 2014. AGU does not track race or ethnicity, as attributes are not constant across the international membership. So our goal to study diversity is limited by available data to sex.

Figure 1 summarizes what we know about the Cryosphere focus group. The focus group currently comprises roughly 2% of AGU members. Approximately 1% of members declined to answer. Our average age was 42 in both 2014 and 2015. Students, the most diverse cohort of members, make up about 27% of the focus group. Regular members, professionals engaged in Earth and space sciences, make up about 70% of the focus group. Associate and life members make up about 1% and 2%, respectively. We clearly see less gender balance in later career stages.

Breakdown of Awards

The Cryosphere focus group oversees three exclusive honors: the Early Career Award, the Innovation Award for Students, and the Nye Lecture, which honors an outstanding cryospheric scientist and his or her ability to present exciting science. It also helps select Union-wide honors, including AGU Fellowships for cryosphere studies, and Outstanding Student Paper Awards for cryosphere research presented at conferences.

These awards cover the entire academic career from student to senior researcher. Figure 1 reports the percentage of male and female awardees, the year of the first award, and the year it was first awarded to a woman. Our data show women are slightly underrepresented (~4%) in student awards and slightly overrepresented (~7%) in the Early Career

Award compared with membership numbers. However, at this time, with only 2 years of membership data, we feel that these awards are likely representative.

As with our membership, award diversity decreases in later career stages. This may be a generational effect; fewer junior women in the past leads to fewer senior women today. For perspective, we looked to longer time series of data outside of AGU.

The longest history comes from *Hulbe et al.* [2010], who documented the sex of first and second authors in International Glaciological Society journals from 1948 to 2010. Female authors represented about 5% of authors from the 1950s through the 1980s, 13% in the 1990s, 16% in the 2000s, and roughly 20% by the end of the study.

Thus, if the women who were publishing in the 1990s are our more advanced career female scientists today, we should expect to see their 13% representation mirrored in senior roles. This time series suggests that our Nye Lecture award reflects past diversity while our Fellows awards exhibit some bias against awards to women.

A Broader View

We look to the percentage of research awards made to female principal investigators (PIs) and women serving in editorial positions for additional context. PIs of NASA Cryospheric Science grants, from 2007 to 2014, were 17% female (according to the NASA Solicitations and Proposal Integrated Review and Evaluation System; see http://bit.ly/nspiresgrants). The U.S. National Science Foundation Division of Polar Programs gave 18% of its awards to female PIs in the period 1997–1999 and 24% during the 4th International Polar Year (2007–2009 [*National Research Council,* 2012]).

Although no cryosphere-specific data were available, the European Research Council's Working Group on Gender Balance reports that in the period 2007–2013, 20% of its Physical and Engineering Sciences Starting/Consolidator grants and 7% of its advanced grants (from 2008 to 2013) went to women.

We also selected three journals, inclusive to cryosphere, that represent the broadness of our field: *The Cryosphere, Journal of Glaciology,* and *Permafrost and Periglacial Processes.* In March 2016 all chief or cochief editors were male, and the editorial boards contained 9%, 18%, and 0% women, respectively.

Although direct comparisons among the various metrics are not possible, they illustrate the environment in which women work and in which they obtain (or fail to obtain) the support and experience needed to progress in their careers. Overall, these broader metrics are similar to those reported by *Hulbe et al.* [2010], supporting our expectation that more women should be earning AGU Fellowships for cryospheric studies.

Into the Future

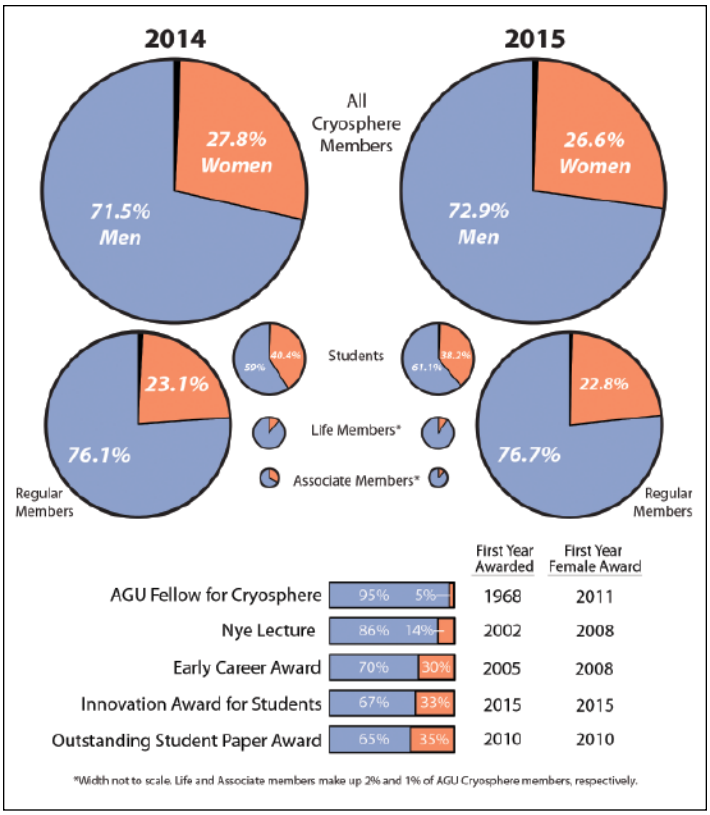
Back to the overarching question: Do AGU Cryosphere awards reflect the currently available diversity statistics?

Our answer is yes, except in the Fellows category. We have actively pursued a diverse set of Fellows applications and expect this category to improve.

Of course, the low representation overall reflects the imbalance of men and women in our field. Women are underrepresented, and inequality escalates with career tenure. Although we do not currently have data, we would expect this trend for minorities as well. Unless bias within the STEM fields is addressed, this imbalance is unlikely to change.

The Cryosphere focus group will continue to track diversity on a biennial basis. We strive to make cryospheric sciences a field with equal opportunity for all who enter so that we have the best minds available to address scientific questions relevant to our global society.

We encourage other focus groups to follow our lead, and we look forward to more studies and research aimed at understanding and improving diversity within cryospheric science, AGU, and STEM fields.



Allen Pope and Kiya Riverman

Fig. 1. (top) Percentage of male and female members of the AGU Cryosphere focus group by membership type. (bottom) Percentage of male and female cryosphere awardees, the year first awarded, and year first awarded to a woman.

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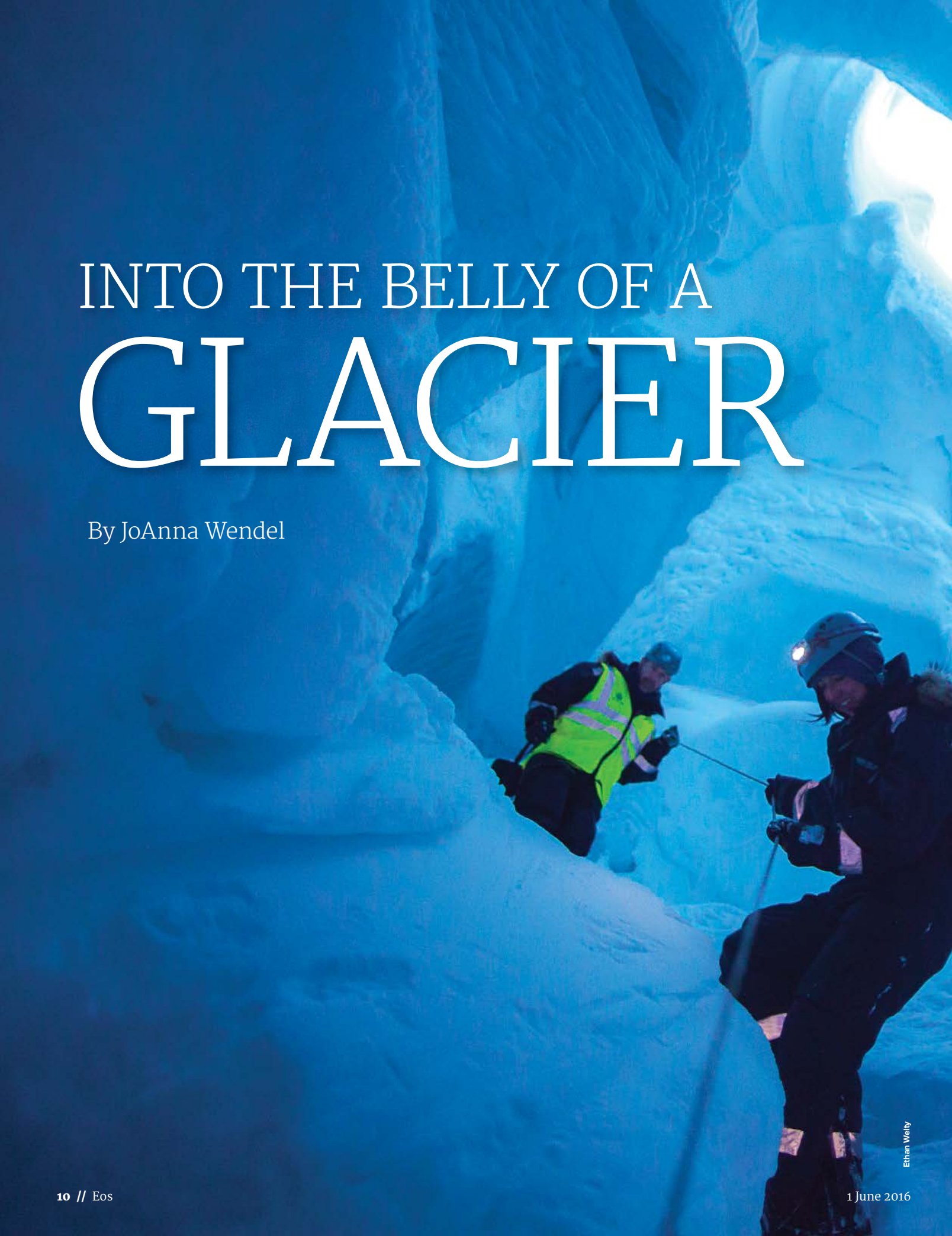
Editor's Note: Lora Koenig is the secretary of AGU's Cryosphere focus group, Robin Bell is president of the focus group, and Derrick Lampkin is the chairman of the focus group's outreach and diversity efforts.

INTO THE BELLY OF A GLACIER

By JoAnna Wendel



Ethan Welty

Ice caving started as a weekend hobby but has now blossomed into a portion of graduate student Kiya Riverman's Ph.D. research.

Dropping into an ice cave is like entering another world: There's no wind, no ambient sound, and no discernible smell—unless you're eating a peanut butter sandwich; then the scent tends to overwhelm the cold, dark space. Headlamps light up sparkling rooms of ice crystals, towering waterfalls, and narrow passages, while heavy ski boots leave footsteps behind where no other human has ventured.

"It's kind of just you and the ice down there, and I love that," said Kiya Riverman, a graduate student at Pennsylvania State University in University Park. Riverman's glaciology research involves climbing, crawling, and squeezing through an ice cave in Svalbard, Norway, in the Larsbreen glacier, every few years. Her research explores how waterfalls form and move within the glacier, which affects its overall hydrology.

Riverman's ice caving colleagues climb down into the cave.

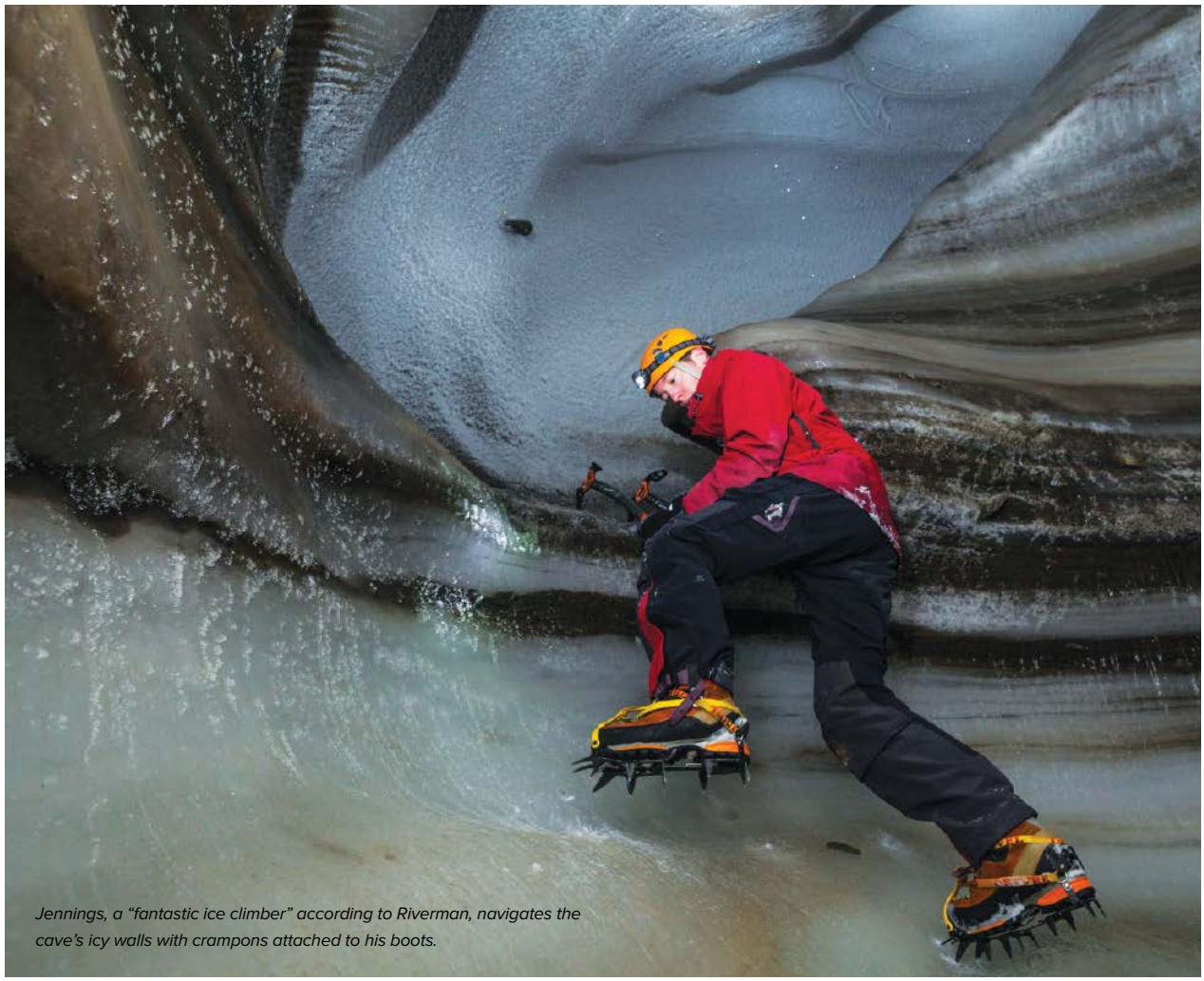
(top left) A student from the University Center on Svalbard explores an icy tunnel in the Scott Turnerbreen ice cave. Credit: Kiya Riverman. (bottom left) Riverman and her colleagues hike 7 kilometers and then ski for an hour to get to the Larsbreen ice cave's entrance. Riverman calls this "easy access." Credit: Kiya Riverman. (above) Stephen Jennings, mountaineer, throws a rope to his caving companions. Credit: Ethan Welty.

Kiya Riverman

Lynn Kaluzienski, a caving colleague of Riverman's, descends a frozen waterfall in Larsbreen ice cave during the 2016 mapping expedition.

In the summer, meltwater from the glacier cuts through the ice, Riverman said, forming and altering cave passageways as it flows down to the earth below. There, under the ice, the meltwater can speed or slow the glacier's movement. By studying the changing pathways of water flow, Riverman hopes to better ascertain how glaciers will respond to climate warming and increased ice melt.

"We're describing the hydrology of this glacier by crawling around inside of it," she continued. "In general, I'd say these systems are incredibly underutilized" in the research community. Not enough scientists actually study glaciers from the inside out, she explained.



Jennings, a "fantastic ice climber" according to Riverman, navigates the cave's icy walls with crampons attached to his boots.

Ethan Welty

The ice cave research started as a fun weekend hobby in 2010 when Riverman was an undergraduate studying abroad in Svalbard. A glaciologist in her program needed help mapping the ice cave, and being an avid caver back in Pennsylvania, Riverman jumped at the chance.

"It's like a fish to water at that point," Riverman said. "Sure, you're in a system that's completely ice-filled instead of rock, but it's a lot of the same kind of exploration mentality that we have in the normal caving world."

In 2014, Riverman traveled back to Svalbard as part of her graduate program and decided to map the cave again. Because the cave is near the town of Longyearbyen and frequently used for tourism (although the guides don't take the tourists very deep), the entrance to the cave is easy to spot; someone always leaves behind a flag denoting the entrance's location under the snow. Riverman and her caving companions just dig it out and rappel down. Earlier this year, Riverman again traveled to the cave to map its icy twists and turns, and she was surprised at how much the cave had changed from her initial adventures 6 years prior. Since her first visit in 2010, the cave now sits noticeably deeper in the ice.

Riverman always takes fellow cavers with her, mostly for safety reasons but also because it's fun.

"There have been some beautiful moments connecting with my fellow scientists underground," Riverman said. Her caving companions have to rely on each other for hours at a time underneath the ice. "The time I get to spend with the people I'm mapping [caves] with is always magical."

There have been some scary moments as well. Once while dangling over a 9-meter drop, safely secured to a rope, Riverman had a brief moment of existential panic about the ice screws that were the only things protecting her from a swift death. Still, Riverman feels drawn again and again to exploring the otherworldly cave.

"To be standing within the system and have some kind of appreciation for how it changes and evolves, that's what keeps drawing me back," Riverman said.

Author Information

JoAnna Wendel, Staff Writer

Check out a video of Riverman in the ice: http://bit.ly/explore-inner-glacier-video.

Training Network for Young Atmospheric Researchers

By Robert F. Banks, Susanne Crewell, Sarah Henkel, and José M. Baldasano

Aerosol-cloud interaction is recognized as the single largest uncertainty in today's climate models. In the fifth report of the Intergovernmental Panel on Climate Change, scientists state with high confidence that aerosols and their interactions with clouds have offset a substantial portion of global average warming due to the effects of well-mixed greenhouse gases. They continue to contribute the largest uncertainty to the total estimate of climate warming. As such, they are a very important component to the planetary boundary layer, the layer of Earth's atmosphere directly influenced by its contact with Earth's surface.

The European Commission, the European Union's executive body, now funds a training network that combines multiple disciplines to exploit innovative atmospheric remote sensing techniques that advance our understanding of aerosol-cloud interaction. The network, called the Initial Training for Atmospheric Remote Sensing (ITaRS), is a 4-year project (2012–2016) providing support for 16 Ph.D. students and young postdocs who are employed at one of nine European research institutions.

ITaRS Framework and Goals

ITaRS comprises 10 associated partners—five of them manufacturers of meteorological instruments, five of them academic research institutions. ITaRS participants work at these partners' facilities, focusing on applying ground-based remote sensing instrumentation to improve our understanding of aerosols and clouds and their interaction in both climate and weather. Figure 1 shows the geographical distribution of the network.

Funding for the positions filled by ITaRS participants is provided through the European Commission's Marie

depositphotos.com/arijazz

Lukas Pfitzenmaier/TU Delft

Hands-on training with advanced instrumentation is an important part of the Initial Training for Atmospheric Remote Sensing (ITaRS) summer schools. Here at the second summer school, Dave Turner of the National Oceanic and Atmospheric Administration explains to some school participants how a Sun tracker works.

Skłodowska-Curie fellowships, grants available to researchers regardless of their nationality and field of research. ITaRS is a subset of the Marie Skłodowska-Curie program's popular Initial Training Networks (ITNs). ITNs aim to improve career perspectives of young researchers by preparing them for a career in both the public and private sectors. ITNs offer young researchers prime appointments at research institutions in an effort to make scientific careers more attractive and eliminate cultural and other barriers to career mobility.

Two thirds of ITaRS fellows are from European Union member states, but fellows also originate from Russia (two), China (one), Pakistan (one), and the United States (one).

A Pan-European Training Program

ITaRS is the first step to developing sustainable pan-European Ph.D. training in the research community that focuses on aerosols and clouds. But how does life in a graduate school work if the students are spread all over Europe?

For the past 3 years the ITaRS training program has included two summer schools that bring together all fellows. The National Institute for Research and Development in Optoelectronics in Bucharest, Romania, hosted the first summer school, Aerosol Remote Sensing, Processes and Applications. Students presented on topics investigated using various ground-based remote sensing instruments (e.g., Raman lidar, Sun photometers), such as evolution of the planetary boundary layer height and determination of aerosol optical properties.

In addition, a field campaign performed at the summer school provided an interesting data set on surface aerosol composition from an aerosol mass spectrometer (AMS) and vertical structure from a multiwavelength Raman lidar. Fellows also produced semiautomated microphysical retrievals for biomass-burning aerosol cases captured by lidar and then evaluated the results using the AMS and Sun photometer retrievals [*Samaras et al.*, 2015]. They found that observations reflected only a small portion of phenomena predicted by mathematics.

The second summer school, on Remote Sensing of Clouds and Precipitation: Observation and Processes, took place on 8–17 September 2014 at the Research Center in Jülich, Germany. Participants benefited from hands-on training with instruments from the Jülich Observatory for Cloud Evolution (JOYCE) site, including a microwave radiometer, scanning cloud radar, micro rain radar, wind lidar, sonic detecting and ranging, and an infrared spectrometer. Participants also investigated polarimetric twin radars in Bonn and Jülich. The summer school was such a success that the U.S. Atmospheric

Radiation Measurement program decided to follow the ITaRS format for a follow-on summer school in 2015.

Two ITaRS fellows, Robert Banks and Lev Labzovsky, attended the 2014 Aerosols, Clouds, and Trace Gases Research Infrastructure (ACTRIS) Winter School on Advanced Analysis of Atmospheric Processes and Feedbacks and Atmosphere-Biosphere Interactions, hosted by the Division of Atmospheric Sciences of the University of Helsinki. The intensive 2-week course took place from 10 to 21 March 2014 at the Hyytiälä Forestry Field Station in southern Finland. Topics relevant to the fellows included remote sensing of vertical aerosol distribution, clouds and aerosol quality-controlled observations, and the synergies between lidar and Sun photometers.

Fellows also engage in network-wide workshops where they are trained in instrumentation, atmospheric physics, and algorithms for the interpretation of the measurements. Perhaps most helpful for broadening applied skill sets, fellows also visit other ITaRS partners for 2- to 4-week training sessions (secondments), during which they get hands-on experience in specific techniques applicable to their individual doctorates.

Between meetings, weekly e-seminars promote communication within the network.

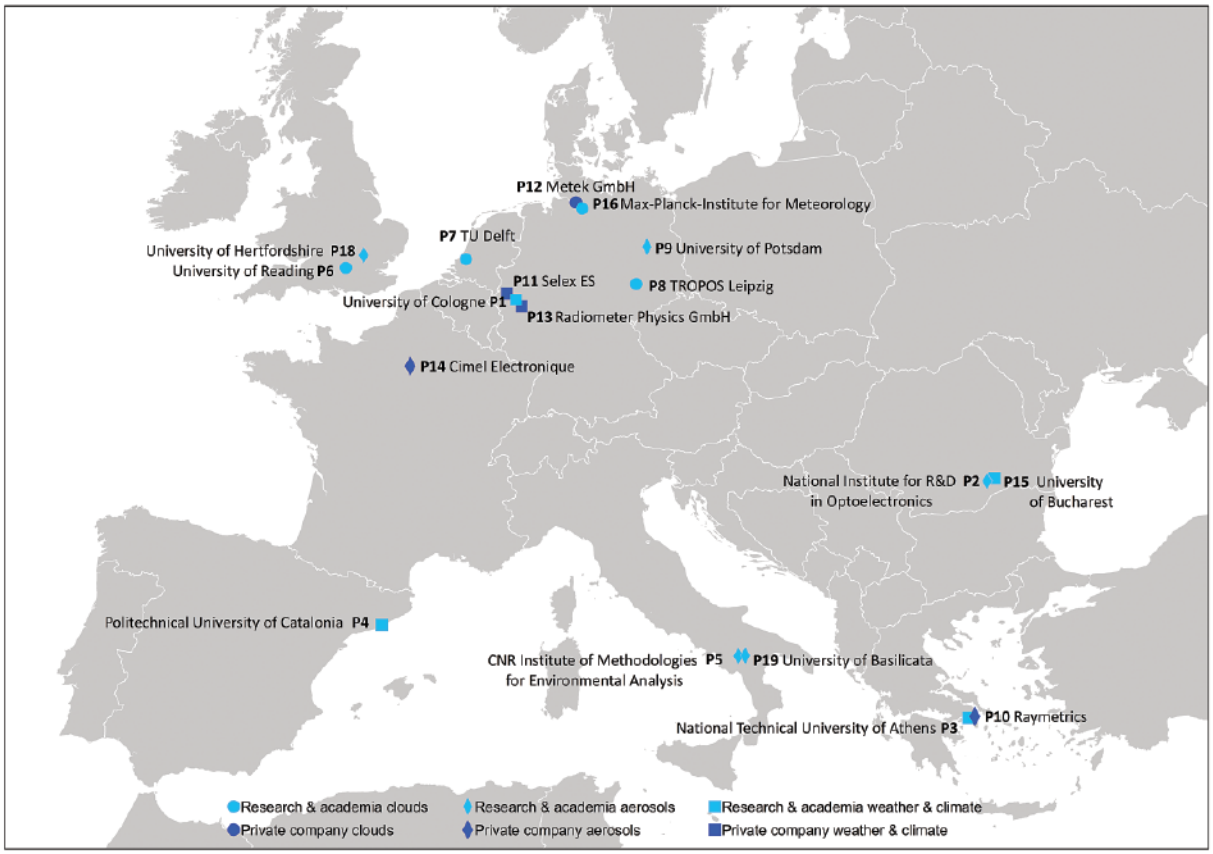
Research Examples

Network events have also led to discussions between instrument experts and scientists from the aerosol and cloud community and helped to refine fellows' Ph.D. topics. In particular, the dialogue with the industrial partners has been useful, leading to better exploitation and development of instrumentation.

The dialogue with industrial partners has been useful, leading to better exploitation and development of instrumentation.

One example of such collaboration occurred when the Leibniz Institute for Tropospheric Research and private industrial partner Meteorologische Messtechnik GmbH performed a series of field measurements. This led the ITaRS fellow at the Leibniz Institute for Tropospheric Research to conduct a study that improved the use of innovative polarimetric techniques for cloud radar.

Fig. 1. Map representing the geographical distribution of ITaRS partners. Linkages are deepened through the fellows' two secondments—2- to 3-week dispatches for hands-on training in a specific technique—typically one to their cosupervisor at another academic partner (P1–P9) and one to an associated partner (i.e., a private company; P10–P19).



Another example is the recent work by *Myagkov et al.* [2015], which considers the influence of antenna amplitude and phase patterns on polarimetric measurements taken with certain cloud radars operating in linear depolarization mode—a method that helps determine the shape and orientation of ice crystals. They discovered a correction algorithm for the linear depolarization ratio and co-cross-channel correlation coefficient, which can be used to better understand how ice crystals aggregate and form rime, the frozen water droplets that can sometimes coat snowflakes.

Lukas Pfitzenmaier/TU Delft

At the first summer school, Cristian Radu (far right) of the National Institute for Research and Development in Optoelectronics explains how Raman multiwavelength lidar works to fellows Athina Argyrouli (left) and Stefanos Samaras.

Participation in Field Campaigns

ITaRS fellows have participated in several international field campaigns to improve atmospheric research. In the summer of 2014, the From Hygroscopic Aerosols to Cloud Droplets (HygrA-CD) and Characterization of Aerosol mixtures of Dust and Marine origin (CHARADMExp) campaigns took place in Greece. Fellows, along with host scientists, are currently analyzing data from these campaigns.

For example, *Banks et al.* [2016] used lidar, radiosonde, and surface meteorological observations from HygrA-CD to evaluate how well phenomena within the planetary boundary layer are simulated within the popular Weather Research and Forecasting numerical weather prediction model. They found that planetary boundary layer schemes that diagnose turbulent mixing in adjacent and nonadjacent model levels (nonlocal closure) tended to reproduce values closest to the observations.

During fall 2014, several ITaRS fellows participated in the Analysis of the Composition of mixed-phase Clouds with Extended Polarization Techniques (ACCEPT) campaign in Cabauw, Netherlands, and presented results in Vienna at the General Assembly of the European Geosciences Union in April 2015. The main objective of ACCEPT was to analyze the composition of mixed-phase clouds with extended polarization techniques.

Outreach

The ITaRS network also facilitates scientific divulgation and outreach. At the first summer school in Bucharest, the fellows developed four short videos to help explain science to the general public (see http://bit.ly/itarsvideo). The program also hosted a debate with local university students on climate change at its first workshop in February 2013 as well as a science show for high school students in September 2013. Most recently, ITaRS fellows have begun enhancing Wikipedia articles involving topics in atmospheric remote sensing.

In addition, the ITaRS network hosted a booth at the Meteorological Technology World Expo 2015 in Brussels. At the booth, interested attendees met fellows, learned about the results of research projects, and discussed their future plans. Two ITaRS partners, Susanne Crewell and José Maria Baldasano, presented at the conference during a trade fair on Tuesday and Wednesday, respectively.

Future Plans

Being part of a nascent network of young applied scientists provides many rewards, says fellow Maria Barrera Verdejo: "The 16 ITaRS fellows are a really strong group; we grow together. We have many opportunities to go to conferences and to organize our own meetings, and I feel that we are lucky to have this position."

Together, the ITaRS fellows will form a new generation of scientists who are able to close the gap between the specialized development of single instruments and atmospheric applications. The final year of funding by the European Commission is 2016; talk of ITaRS2 is ongoing.

More information is available at http://www.itars.net.

Acknowledgments

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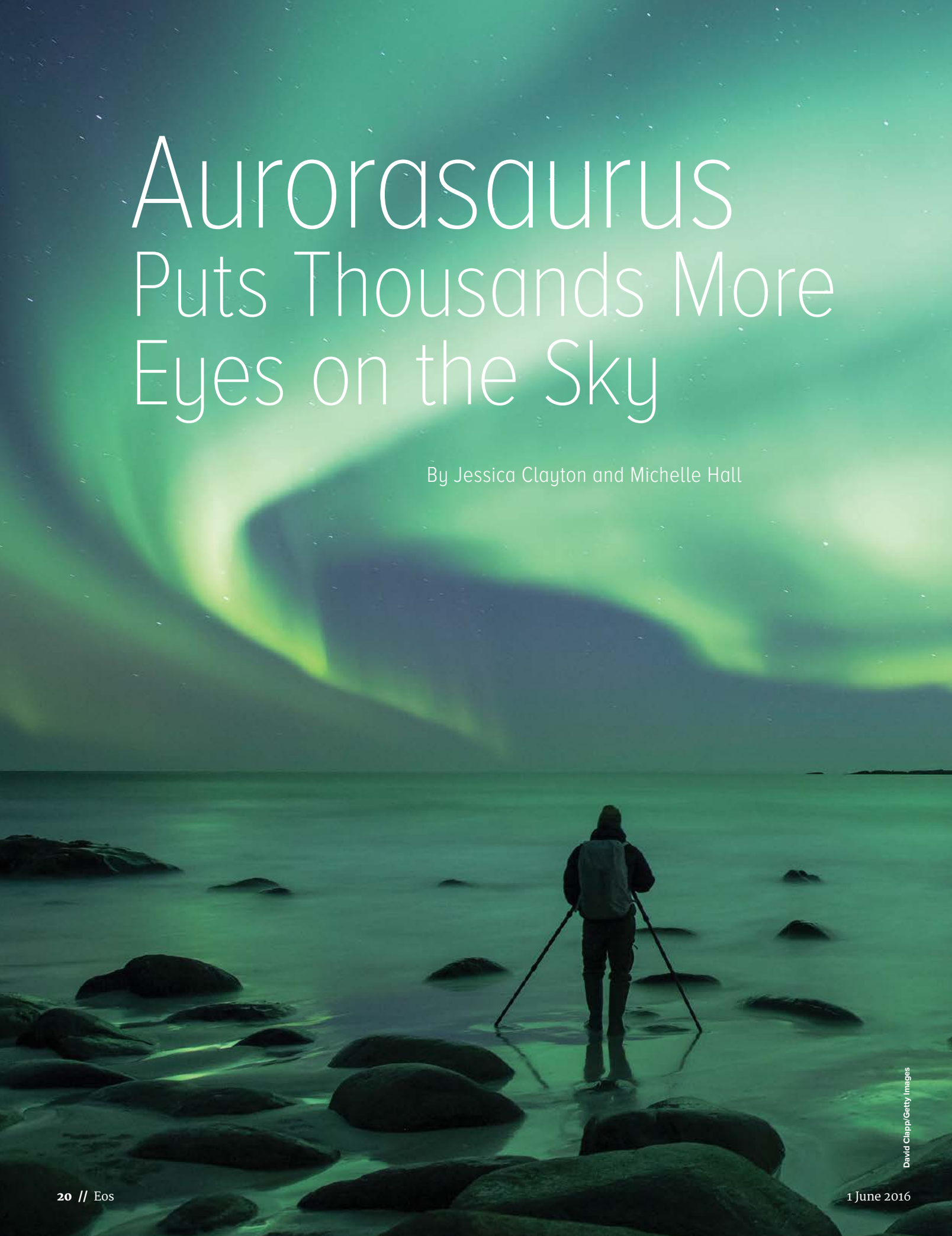
Aurorasaurus Puts Thousands More Eyes on the Sky

By Jessica Clayton and Michelle Hall



David Clapp/Getty Images

Citizen scientists share real-time auroral sightings to advance research.

Auroras are beautiful displays of dancing, colored lights in the sky. Few people live far enough north or south to see auroras often, but the celestial shows draw travelers from around the world and remain a popular bucket list item. The year 2015 was good for fulfilling those dreams, as widespread auroras glowed on St. Patrick's Day in March and again near the summer solstice in June.

When auroras lit up the skies in spring 2015, citizen scientists around the world sprang into action, sharing reports about the colors and height of the auroras they witnessed and helping to verify data collected from others. This collaboration was made possible by the National Science Foundation–funded Aurorasaurus community, which serves as a centralized hub where citizen scientists can gather and share aurora

Aurora over Bozeman, Mont., photographed by Joseph Shaw, a member of the Aurorasaurus Scientist Network, in November 2004.

data on the project's website, http://aurorasaurus.org, and mobile apps [*MacDonald et al.*, 2015].

Why Do We Need Auroral Research?

Auroras occur in Earth's upper atmosphere, usually 100–200 kilometers above the surface. They fall into the category of "space weather" because they are the direct result of geomagnetic storms. These storms occur when the solar wind—a stream of charged particles and magnetic fields coming from the Sun—disturbs Earth's magnetic field. Geomagnetic storms have the potential to severely disrupt society and technology, interfering with signals to and from GPS, for example. Under some conditions, ground- and space-based electrical systems can be damaged by the same high-energy particles responsible for auroras [*National Research Council*, 2008].

Currently, relatively few instruments monitor for geomagnetic storms. These storms tend to develop 2–3 days after bursts of activity on the Sun, but the best measurements of their strength happen roughly 1 hour before they collide with Earth's magnetosphere.

Models suggest what regions will likely see auroral activity, but geomagnetic storms can be unpredictable and change rapidly. Aurorasaurus aims to put more eyes on the sky to create a real-time map of auroral visibility. Then, existing visibility models can be compared with actual ground observations from citizen scientists, providing data for model improvements and giving scientists a better understanding of auroras.

Collecting Observations

Aurorasaurus collects auroral observations for the real-time visibility map using two different methods.

First, observers file observation reports on the Aurorasaurus.org website and the mobile app, and software plots the report's position on a map on the basis of the observer's location. These reports allow users to attach images and share details about what they witnessed. Images are important because the appearance of an aurora may change dramatically with time or vantage point. Users share their approximate location, time, and observed colors, as well as the aurora's height in the sky. Users can indicate whether they are seeing discrete arcs (distinct lines or curves) or a diffuse glow (widespread, no distinct shape) or pulsating patches.

The second type of data collected and displayed on the map comes from Twitter users, many of whom may never have heard of Aurorasaurus. In recent years, an upswing in tweets referencing the keywords *aurora*, *northern lights*, and *southern lights* has coincided in time with widespread auroral activity [*Case et al.*, 2015a].

Many people like to share the news of their auroral sightings with friends. Aurorasaurus captures tweets with these keywords, filters them, and places them on the visibility map, making it possible to be a citizen scientist without even knowing it.

When Will the Next Big Aurora Occur?

Unfortunately, there is no way to know for sure when the next big aurora will happen. Bright auroras that cover large areas are most common after coronal mass ejections (CMEs) erupt from the Sun. CMEs are unpredictable, but their frequency is tied to an 11-year cycle of activity on the Sun. (The most recent peak was in 2014.)

Technically, auroras are always happening because the solar wind is always blowing charged particles from the Sun toward Earth, but most of the time they are much too faint to be detected. When they can be seen, they are usually in remote areas with few people.

When bright auroras are predicted, Aurorasaurus spreads the word. The project offers a location-based notification system to alert users that auroras might be visible based on nearby observations and tweets.

At any time, Aurorasaurus users can check the solar wind power plot (see http://aurorasaurus.org/storm-tracker), which shows data for the most recent 36-hour period. This plot is a good general indicator of upcoming auroral activity.

Joseph Shaw, a member of the Aurorasaurus Scientist Network, photographed this aurora over Poker Flat Research Range near Fairbanks, Alaska, in March 2011.

Educating and Engaging Citizen Scientists

Aurorasaurus relies heavily on user input, so the project aims to build a community of educated and enthusiastic contributors. This goal is somewhat challenging for a project that cannot predict when it will need to call its volunteers to action. Fortunately, the majority of Aurorasaurus users (55%) self-identify as aurora enthusiasts, and 30% participate in other online aurora communities. These users are the lifeblood of the project.

During times when auroras are infrequent, users are encouraged to learn about the science behind auroras and take quizzes to test their knowledge. In-depth infographics are available to address how layers of color form. Users share news and address questions from other users on a blog: http://blog.aurorasaurus.org.

Users also have opportunities to interact with space weather scientists who volunteer through the Aurorasaurus Scientist Network (see http://www.aurorasaurus.org/about-us). These group members share their experiences as auroral researchers through the blog and during live TweetChat and Google Hangouts events aimed at helping the public understand auroras and appreciate space weather research. Aurorasaurus data are even used in some classrooms. Educators participating in a NASA Heliophysics project have students compare local magnetometer data with the real-time solar wind power data on Aurorasaurus.org.

Is It Real?

Aurorasaurus users have another important role: verifying "positive tweets" about the aurora that represent unique,

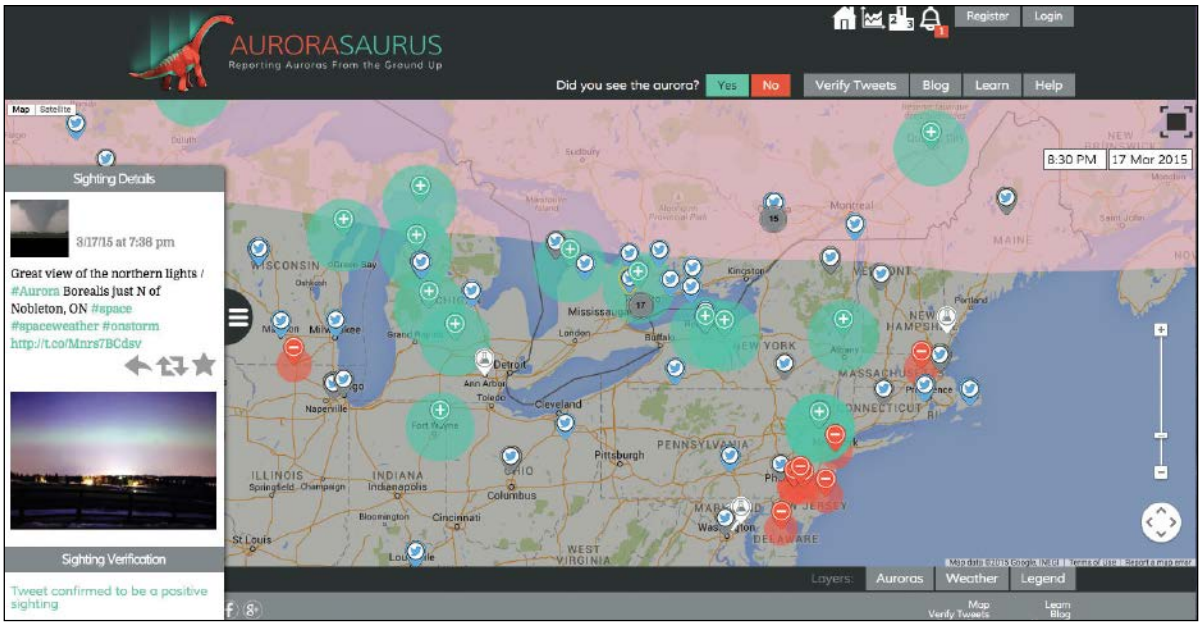


Fig. 1. Users reported widespread aurora sightings in real time on 17 March 2015 on Aurorasaurus.org. Many sightings occurred south of the auroral oval, the pink region on the map, where the aurora is predicted to be visible overhead. Legend: auroral reports from citizen scientists, green; tweets positively verified as auroral sightings, blue with bird; tweets not verified or not a sighting, gray with bird; and locations where citizen scientists did not see the aurora, red.

positive, real-time sightings. To be classified as a positive tweet, it must be sent by the person making the observation: "I just saw the aurora." On the other hand, "My aunt Millie in Montana just saw the aurora" would be marked negatively because the tweeter and Aunt Millie might actually be very far apart. "I hope I get to see the aurora tonight" would not count as a positive observation, nor would a retweet of an aurora image, where tweeters around the world pass along an interesting tweet to their networks of followers.

Spam filters remove references to the city, business, and princess that share the name Aurora. True references to the celestial phenomenon (meaning real-time tweets that are relevant and resolved into the correct location) must still be assessed by humans.

Early Results After Two Geomagnetic Storms

Most Aurorasaurus data collected thus far originated from the March and June 2015 geomagnetic storms. Around St. Patrick's Day, Aurorasaurus users filed 170 observation reports (Figure 1), many of which included photos [*Case et al.*, 2015b]. Hundreds of tweets were captured; users verified 420 of them as unique, positive, real-time sightings of auroras. Interestingly, many of the observations occurred quite far south of the predicted viewing region, indicating that models could be improved with these new data points [*Case et al.*, 2016].

Recently, Aurorasaurus rolled out a map with the new Oval Variation, Assessment, Tracking, Intensity, and Online Nowcasting (OVATION; see http://bit.ly/OVATION-model) prime model for the auroral oval, as well as an estimated "view" line. Aurorasaurus will continue to tweak its algorithms to provide better forecasts and tools.

Using Aurorasaurus, scientists and citizen scientists will continue tackling the challenges of predicting space weather. When the next storm strikes, Aurorasaurus users will spring into action, ready to share their observations of this beautifully intriguing phenomenon.

Acknowledgments

This material is based upon work supported, in part, by the National Science Foundation (NSF) under grant 1344296. Satellite-based space weather data and models used by Aurorasaurus are provided by the National Oceanic and Atmospheric Administration's Space Weather Prediction Center. Any opinions, findings, and conclusions or recommendations are those of the authors and do not necessarily reflect the view of NSF.

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Upcoming Leadership Elections

AGU Governance Committee and section/focus group officers are pleased to announce the slate of candidates for the 2016 AGU election, which opens on 29 August and is to choose leaders to serve in 2017–2018. Names of candidates for the AGU Board of Directors, the student and early-career members of the AGU Council, and section/focus group presidents-elect and secretaries are posted online at elections.agu.org.

Voting Is for AGU Members

Voting is a right of membership. To be eligible to vote in the 2016 AGU election, you must be a member in good standing, which requires joining or renewing your membership by 1 August 2016. In addition to paying your dues, please go online and ensure that your section/focus group affiliations are up to date. AGU allows members to belong to as many sections/focus groups as desired to encourage interdisciplinary and transdisciplinary research. Each member will be provided the opportunity to vote for AGU Board members, student and early-career positions of the Council, and leaders of all sections/focus groups with which they are affiliated.

Timeline

AGU bylaws require that the proposed slates be announced to the membership 30 days before the ballot is finalized. The bylaws also allow for additional nominations from the general membership by petition, provided that each petition is signed by at least 1% of the full voting members of the Union or section/focus group, as appropriate. This year petitions must be received no later than 6 June. Each nominee must be an AGU member and provide a letter with the petition agreeing to serve if elected. Please send petitions to Carol Finn, Past President, AGU, 2000 Florida Ave., NW, Washington, DC 20009, USA, or send them by email to cenderlein@agu.org.

The Governance Committee plans to announce the final ballot on the AGU website by early July. The election will be held from 29 August through 27 September 2016. Election results will be announced in October, and newly elected members of the Board and Council will be invited to observe Board and Council meetings held in conjunction with Fall Meeting in San Francisco. Elected members will serve 2 years, from 1 January 2017 to 31 December 2018.

Emails with election information will go out to all eligible voters beginning in August. It is important for members to vote and provide feedback on the voting process so that Governance Committee members and staff can continue to improve the voting experience for our members.

AGU Board of Directors Candidates

Board candidates will compete for four open positions on the Board in this year's election: president-elect and three directors. AGU's rotation strategy is designed to retain about 50% of elected members each term to ensure leadership continuity. Continuing members for the 2017–2018 term include the current AGU president and president-elect in their new positions, the international and general secretaries, three directors, and the executive director/CEO (nonvoting).

> The election will be held from 29 August through 27 September 2016.

AGU Council Student and Early-Career Candidates

There are six permanent positions for student and early-career members on the AGU Council. The Governance Committee invited volunteer leaders familiar with AGU's governance structure to submit nominations for two open student and early-career positions. Four student and early-career members will continue for a second term.

Section/Focus Group Candidates

Each section/focus group selects its president-elect and secretary candidates. The current presidents-elect will move up to assume the president position, ensuring leadership continuity. Some sections/focus groups also asked current secretaries to serve a second term.

Section/focus group presidents and presidents-elect serve as members of the AGU Council, along with the AGU president-elect, the chairs of three standing committees (Honors and Recognition, Meetings, and Publications), six students and early-career scientists, the AGU president (nonvoting), the executive director/CEO (nonvoting), and up to five at-large appointed positions.

Leadership for the Future

The AGU Governance Committee is charged with identifying and developing leadership within AGU to advance the strategic plan and strengthen the governance model. This year the committee, chaired by Carol Finn, AGU past president, adapted the highly successful process used to select student and early-career candidates in the past two elections to create a new process for nominating Board directors.

Current AGU leaders were asked to identify potential Board candidates, and those who met the leadership criteria were invited to apply. This resulted in the deepest pool of qualified candidates in the history of AGU. Governance Committee members then interviewed selected candidates before finalizing the slate. Candidates not on the ballot will be asked to consider serving in other leadership positions.

The Governance Committee's six members are Julie Brigham-Grette, Mary Anne Carroll, Hans Lechner, Catherine McCammon, Holm Tiessen, and George Tsoflias.

Renew Your Membership (If Needed) and Vote

AGU is offering a strong slate of candidates for 2017–2018 positions. Please exercise your right to influence the organization's decisions and its future by making certain your membership is current now and by voting in late August for the candidates you feel are the most qualified to lead our Union.

By **Carol Finn,** AGU Past President and Governance Committee Chair; email: pastpresident@agu.org

Volcanic Lightning Could Aid Hazard Response During Eruptions

A volcanic ash plume dwarfs the city of Puerto Montt in southern Chile just after the start of the eruption of Calbuco volcano on 22 April 2015. The radially expanding umbrella cloud is clearly visible, with ash moving in different directions due to wind shear.

In the evening of 22 April 2015, Calbuco volcano began to erupt, forcing more than 6500 nearby residents to evacuate. For several days, ash ejected by the eruption disrupted air travel and damaged buildings in Chile, Argentina, and Uruguay. Calbuco is a 2015-meter stratovolcano located in southern Chile that hadn't erupted since 1972. Its last major eruption, in 1961, also produced an ash plume. Now researchers have used satellite and lightning data to reconstruct the 2015 eruption and its behavior.

Van Eaton et al. used data from the Geostationary Operational Environmental Satellite 13 (GOES 13) to track the growth of the ash-rich "umbrella cloud" that reached several kilometers above the volcano. The plume dispersed to the north and northeast, depositing a total of about 0.5 cubic kilometer of ash.

The eruption also caused more than 1000 cloud-to-ground lightning flashes. The researchers investigated the timing and location of the strokes using data from the World Wide Lightning Location Network, which uses ground sensors to detect lightning's electromagnetic signals.

The scientists found a sharp increase in lightning flashes close to Calbuco just after the formation of pyroclastic density currents (PDCs)—destructive flows of ash, gas, and other volcanic debris that swept down the flanks of the mountain. On the basis of thermodynamic modeling, the authors propose that the intensified lightning was triggered by an electrical charge layer created by the PDCs.

The intensified lightning and formation of PDCs also coincided with the end of upwind growth of the ash umbrella—that is, the radial expansion of the umbrella cloud in the upwind direction. During eruptions of similar volcanoes, the researchers speculate, these combined observations could be used as a signal that PDCs have formed.

The team also found that certain changes in volcanic lightning and plume dynamics corresponded to the eruption's start time, duration, and material ejection rate. For similar eruptions, such changes could be used to predict ash dispersal and minimize hazards to nearby communities and infrastructure. (*Geophysical Research Letters,* doi:10.1002/2016GL068076, 2016) —**Sarah Stanley, Freelance Writer**

Drifting Floats Reveal Nitrate Patterns in the Mediterranean Sea

The Mediterranean Sea, a semienclosed basin nearly entirely enveloped by central western Europe and North Africa, is one of the largest nutrient-depleted oceanic regions in the world. Despite the key role of nutrients (in particular nitrate) in controlling ocean life, its dynamics is still poorly understood. For the Mediterranean, observations across the basin are, up to now, too scarce to describe seasonal and year-to-year processes accurately. The recent emergence of automatized floating platforms equipped with specific miniaturized sensors appears to be an unprecedented opportunity to explore the ocean and Mediterranean physical and biological interactions.

In their study, *Pasqueron de Fommervault et al.* analyzed the distribution of nitrate concentration in the Mediterranean, for the first time using floats equipped with bio-optical sensors. The researchers used data from a set of five free-drifting biogeochemical Argo floats simultaneously deployed in the Mediterranean in 2013 as part of the French Novel Argo Oceanic Observing System program. Between 2013 and 2014 the floats collected almost 500 nitrate profiles, which were compared with a historical database of more than 5000 nitrate concentration profiles from the basin, spanning the 1961–2010 period.

The results allowed the scientists to better describe the seasonal variability and to examine the role of shorter-timescale processes. The analysis revealed that on the surface, where most ocean life exists, nitrate concentrations significantly varied with the seasons only in the northwestern region of the Mediterranean Sea, peaking in abundance in January, February, and March and tapering off throughout the rest of the year. This observation directly mirrors changes in the annual maximum depth of the mixed layer, which is the upper region of the sea where turbulence mixes up water, creating a uniform layer. In this region, the winter deepening of the mixed layer, induced by wind and heat loss, is undoubtedly the primary source of nitrogen for surface water during the year. In the rest of the Mediterranean, surface nitrate concentrations showed low seasonality. Unexpectedly, an important variability was observed in the subsurface and intermediate layers and was related to mesoscale features such as eddies, as confirmed by satellite information. Results also mapped out how the vertical distribution of nitrates affected phytoplankton in the sea. At the seasonal scale the peculiar nitrate situation of the northwestern region of the Mediterranean fostered a dramatic increase of spring phytoplankton concentration.

In spring 2015, 14 additional biogeochemical Argo floats were deployed across the Mediterranean Sea, which may provide scientists with a new data set to confirm previous results and to further elucidate nutrient dynamics in the Mediterranean. (*Journal of Geophysical Research: Oceans*, doi:10.1002/2015JC011103, 2015) **—Kate Wheeling, Freelance Writer**

Nitrogen Garners Starring Role in Refined Earth System Model

Global climate computer models like the Community Earth System Model (CESM) bring together a range of physical, chemical, and biological processes to create a complex portrait of the changing global climate. One portion of CESM is the Community Land Model, which represents the climate impact of terrestrial ecosystems. Plants play an important role in mediating carbon exchange between the land and the atmosphere by fixing atmospheric carbon dioxide (CO_2) during photosynthesis. Nitrogen is a limiting factor that plants rely upon to get the CO_2 they need. Nitrogen taken up through the plant's roots is a key factor regulating the chlorophyll and Rubisco enzyme required for photosynthesis and mitochondrial enzymes that power the plant with adenosine triphosphate (ATP) energy and regulate respiration.

In a recent study, *Ghimire et al.* question whether nitrogen's role in regulating carbon exchange is properly accounted for in the most recent version of the Community Land Model (CLM4.5). The team found that the model underestimates how much CO_2 plants fix each day in scenarios where nitrogen is a limiting factor, an error that nudges the model's intricate portrayal of interconnected systems away from reality.

The authors reasoned that the problem rests with the current model's method for calculating the relationship between a plant's nitrogen uptake and carbon fixation. CLM4.5 uses instantaneous downregulation to account for limitations associated with nitrogen availability. In this method, nitrogen limitations are initially ignored in photosynthesis calculations, and nitrogen availability is accounted for by downregulating the calculated potential photosynthetic rate. In their new approach, the team used the predicted amount of nitrogen comprising the Rubisco enzyme in plant leaves to explicitly constrain photosynthesis. This approach allowed them to use leaf trait observational data to constrain the model.

Son of Groucho, CC BY 2.0 (http://bit.ly/ccby2-0)

A new study suggests that tree roots are as important as leaves when accounting for nitrogen's role in Earth system land models.

The authors found that CLM4.5 does not represent nitrogen's role as a limiting factor in photosynthesis in another important way; that is, it links root nitrogen uptake to processes that occur in the leaves rather than in the roots. Since a range of chemical and physical factors influences how efficiently roots access soil nutrients, the team accounted for these root-related processes in calculating how much nitrogen plant leaves have to work with.

The team found that by altering the existing CLM4.5 model to more accurately represent nitrogen's relationship to photosynthesis, they could more accurately represent carbon fixation in photosynthesis, leaf area, and biomass. By providing an improved, more comprehensive understanding of terrestrial carbon cycling, the model serves as a more useful tool for understanding global climate. (*Journal of Advances in Modeling Earth Systems (JAMES)*, doi:10.1002/2015MS000538, 2016) **—Shannon Kelleher, Writer Intern**

Hitting the Slopes

When raindrops hit exposed soil on a hill, each individual drop has a bomb-like effect. Depending on their size and the speed at which they come into contact with the earth, raindrops can displace soil grains on impact. Detached soil particles are more likely to be carried away by runoff. In sloping areas, unabsorbed water can flow downhill in a thin sheet, carrying soil particles already loosened by raindrops. Over time, hills can be reshaped by both rain splash transport and sheetwash erosion.

Thomas Dunne

On young, tectonically active terrain in central California—like these hills in the University of California Sedgwick Reserve in Santa Barbara County—water-eroded hillslopes are steep and have short upper convexities.

Rain splash transports can account for the short, steep slopes with convex profiles in the Wyoming badlands, but in many other water-eroded landscapes in subhumid regions, hills have long convex portions that resist incision by channels. From these observations, *Dunne et al.* wondered whether rain splash transport alone might generate these observed landscapes, given the constraints of time and climate.

To this end, the researchers were interested to see what conditions were necessary for rain splash to affect the shapes of hills. The team conducted field experiments to create an equation for rain splash transport that accounted for factors such as the type of soil, raindrop size, the mean annual rainfall in the area, and the slope of the hill. The equation was able to calculate sediment transport rates for a range of humid and subhumid climates.

The researchers applied the equation to known landscapes in eastern and southern Africa, where there are few other perturbations that could affect the formation of convex hills. They found that the equation predicting sediment transport did not match the actual shapes of hills. The scientists argued that in these instances, the only transport process that is sufficiently powerful to account for the impressively long, convex hill shapes is sheet erosion, rather than rain splash erosion. (*Journal of Geophysical Research: Earth Surface*, doi:10.1002/2015JF003737, 2016) **—Wudan Yan, Freelance Writer**

A Decade of Progress in Stratospheric Aerosol Research

Tiny particles suspended in the atmosphere, known as aerosols, are typically found in a distinct layer in the lower stratosphere, between about 15 and 25 kilometers above Earth's surface. These particulates are composed primarily of sulfuric acid/water solution droplets, where the sulfur component originates from predominantly natural sources, particularly, powerful volcanic eruptions. Aerosols reflect incoming sunlight and can increase the reflectivity of clouds, which means their presence typically cools Earth's climate. This critical role has led to controversial geoengineering proposals to manipulate the planet's aerosol layer to help counteract a warming climate.

Following a decade of concerted scientific research, *Kremser et al.* provide a comprehensive overview of the advances since 2006 in our understanding of the sources, sinks, and properties of stratospheric aerosols and their potential effect on global climate. These include an estimated increase of 1.5 times the net flux of sulfur from the troposphere to the stratosphere, compared to the last comprehensive review on stratospheric aerosol in 2006, and the detection of small amounts of nonsulfate particulates (including organics and black carbon) in the aerosol composition.

According to the researchers, one of the most significant developments since 2006 is the improved agreement between in situ and space-based measurements of aerosol properties during periods of reduced volcanic activity. The improvement of these data sets, which are core inputs for climate model simulations, as well as the increased number and increased sophistication of chemistry-climate models, has greatly enhanced the representation of stratospheric aerosol processes in climate models during the last decade. Most of these models are now coupled with solar radiation and/or chemistry modules that can account for important feedbacks, allowing climate models to account for changes in hydrologic and carbon cycles as well as changes in the biosphere and cryosphere.

Timothy Marvel, SSAI, Hampton, Va.

A view of Earth from space, visualizing the stratospheric aerosol layer.

Despite significant progress, however, the researchers acknowledge that many crucial research challenges regarding stratospheric aerosols remain. These include quantifying the contribution of man-made sulfur dioxide emissions to the stratospheric aerosol layer and identifying the role of nonsulfur compounds, whose potential influence on chemical reactions is currently not accounted for in most stratospheric aerosol models. The climate model community is aiming to incorporate the stratospheric aerosol layer as an interactive element into global climate models, so that future simulations can assess the role of aerosol in a changing climate. Observations of stratospheric aerosol and its precursors remain necessary to test the reliability of climate model simulations in the future. (*Reviews of Geophysics*, doi:10.1002/2015RG000511, 2016) **—Terri Cook, Freelance Writer**

Modeling the Effects of Clouds on Climate

NASA

An image of hole-punch and canal clouds forming over the Bahamas. Ice clouds are blue in this image. As ice forms, it precipitates readily, thinning the cloud.

Clouds have a complex and intricate relationship with climate. They can cool Earth's surface by reflecting the incoming rays of the Sun, but they can also warm the atmosphere by absorbing the heat emitted from the planet's surface. Climate, in turn, can affect the clouds. This relationship is complicated by the fact that not all clouds are created equal; clouds that are supercooled with temperatures between 0°C and -40°C consist of a mixture of liquid and ice, and these two phases have different microphysical and radiative properties. Liquid-filled clouds are composed of small droplets that have a higher albedo (the whiteness of the cloud, or its ability to reflect sunlight) than ice clouds, which contain larger and less reflective ice particles.

Because of the difficulties inherent in representing the dynamics of mixed-phase clouds, there is a lot of variation in how they are portrayed in global climate models (GCMs). Here *McCoy et al.* show this diversity using the temperature at which ice and liquid are equally prevalent within clouds (T5050). The researchers calculated the T5050 for 26 different global climate models.

They found that the T5050 affected clouds in the current climate in two different ways. In models where T5050 was high (that is, ice forms at warmer temperatures), there was less liquid in supercooled clouds and more ice, which makes sense. However, in these same models, the cloud cover was found to be higher—which did not make sense. Ice crystals should precipitate more readily and decrease the cloud cover, not increase it. The occurrence of cloud albedo and coverage were having compensating effects on the total amount of sunlight being reflected in a given climate model. That is to say, the clouds in high-T5050 models were less white because they were composed of ice rather than liquid, but there were more of them. The combination of these effects led to roughly the same amount of light being reflected by all the different GCMs, even though their individual cloud properties varied widely.

Next, the authors investigated how this apparent tuning between mixed-phase properties and cloud cover affected the cloud feedback. In models with a higher T5050, more ice was available in the current climate to transition into bright liquid droplets as the climate warmed. Because of this, the cloud feedback in regions with lots of mixed-phase clouds was more negative in high-T5050 models. One would expect that the climate sensitivity in these models would be lower. However, in high-T5050 models, the cloud coverage in the subtropics was found to decrease as the climate warmed, leading to a positive cloud feedback in that region. This effect appeared to be due to tuning between cloud cover and mixed-phase partitioning in the current climate, but it led to the subtropical and extratropical cloud feedbacks roughly compensating each other.

Finally, the team reports that the cloud albedo feedback in middle to high latitudes might be "unrealistically negative" in the models examined because the measures of T5050 in the GCMs examined in this study were higher than inferred by either satellites or ground-based lidar observations. This result is consistent with other recent research. The authors note that mixed-phased clouds must be more carefully vetted in future models to reduce biases in albedo and to reduce the uncertainty in cloud feedback and climate sensitivity. (*Journal of Advances in Modeling Earth Systems (JAMES)*, doi:10.1002/2015MS000589, 2016) **—Wudan Yan, Freelance Writer**

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ENVIRONMENTAL SCIENCE

Faculty Position. The South University of Science and Technology (known as SUSTC or SUSTech) (http://www.sustc.edu.cn/en) is a public university founded in the Shenzhen Special Economic Zone of China. It is intended to be a top-tier international university that excels in interdisciplinary research, nurturing innovative talents and delivering new knowledge to the world. SUSTC is conducting a global search for talented faculty who are also innovators and trailblazers. School of Environmental Science and Engineering at SUSTC invites applications for tenure-track and tenured faculty positions in broadly defined environmental science and engineering. Positions are immediately available at all ranks. Highly competitive salaries and start-up packages will be provided. The successful candidates will have great opportunities to advance environmental research in China as the country faces up to enormous challenges in achieving environmental sustainability.

Applicants should have a Ph.D. degree in a water, air, or earth system related discipline. Candidates must have a proven track record of high-quality scientific publications and must have excellent communications skills. Those interested are invited to apply by submitting the following material electronically to iese@sustc.edu.cn: 1) Curriculum Vitae (with a complete list of publications); 2) Statement of research interests; 3) Statement of teaching philosophy; 4) Selected reprints of three recent papers; and 5) Names and contact information of five references. Review of applications will begin immediately and continue until the positions are filled.

BIOGEOSCIENCES

Carbon Emissions and Fluxes Research Scientist

The Jet Propulsion Laboratory, California Institute of Technology, located in Pasadena, California invites applications for a full-time scientist to join the Carbon Cycle and Ecosystems group to conduct research on the global carbon cycle utilizing regional and global scale terrestrial carbon and atmosphere models with ground, aircraft, and satellite data to quantify regional and global scale carbon fluxes.

The selected candidate will be working in a highly collaborative flight project and research environment and will analyze and interpret data from an array of instruments, present their research at conferences and in journal articles, develop proposals for NASA ROSES solicitations and other funding opportunities, and participate in establishing the science foundation and requirements for future science missions. The selected candidate will also support scientific analysis of data from the OCO-2/3, CARVE and will be expected to work with other scientists within the Carbon Cycle and Ecosystems Group and elsewhere on lab.

Requires a Ph.D. in Physics, Geophysics, or related technical degree. An additional three years of related experience is desired along with an established reputation as a researcher in the carbon cycle sciences as evidenced by a strong record of peer-reviewed publications and presentations at major international scientific meetings and conferences. The candidate must have demonstrated experience using remotely sensed data of atmospheric composition and vegetation to evaluate carbon cycle fluxes and processes.

To view the full job description and apply, visit: http://Careerlaunch.jpl.nasa.gov/ (Job ID #2016-6333). Applications will be reviewed as they are received, and should include a curriculum vitae, list of peer-reviewed publications, names and contact information of three references, and a statement of research interests. JPL/Caltech is an equal opportunity/affirmative action employer.

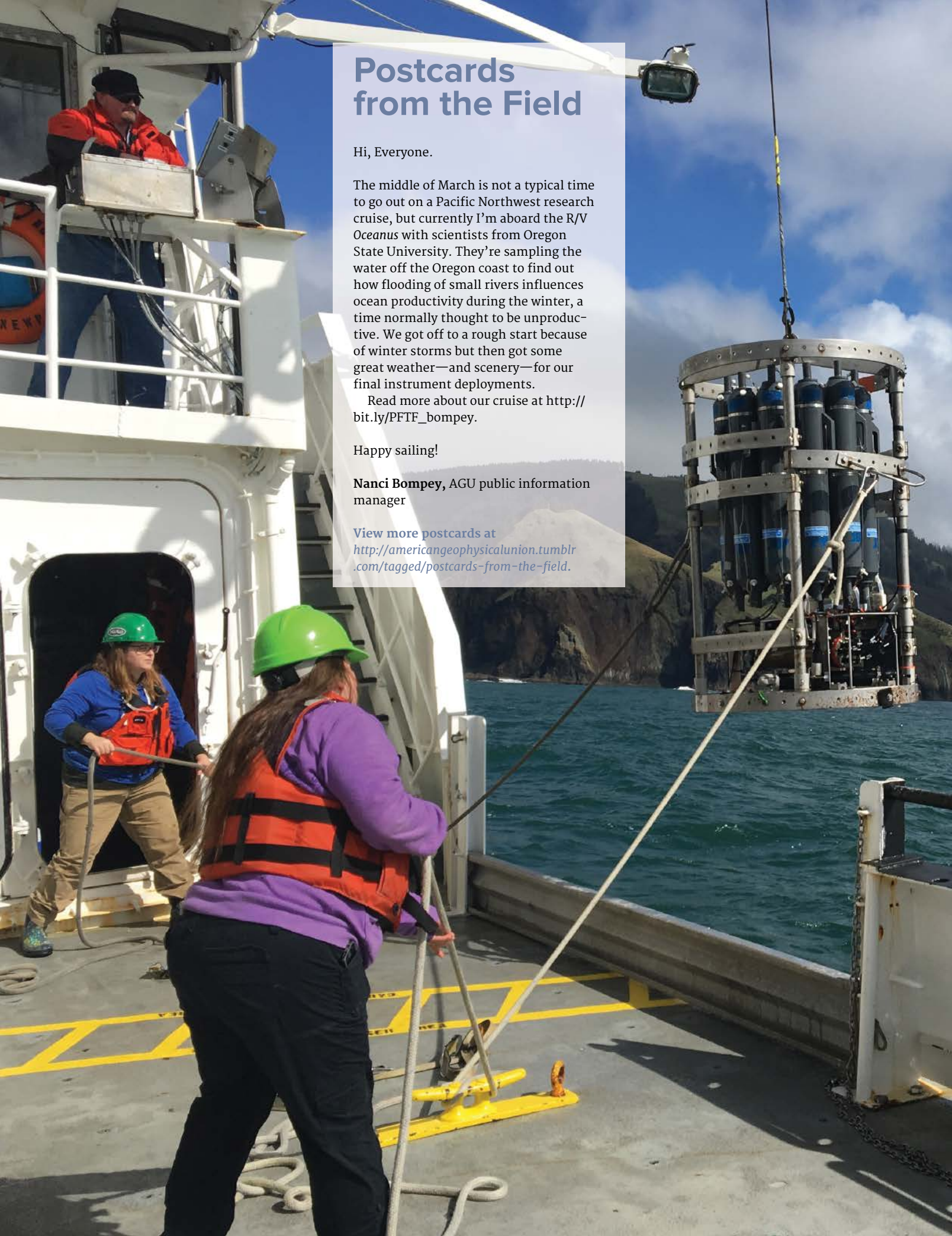
ARL

ARL Distinguished Postdoctoral Fellowships. The Army Research Laboratory (ARL) is the nation's premier laboratory for land forces. The civilians working at ARL and its predecessors have had many successes in basic and applied research. Currently, ARL scientists and engineers are pioneering research in such areas as neuroscience, energetic materials and propulsion, electronics technologies, network sciences, virtual interfaces and synthetic environments and autonomous systems. They are leaders in modeling and simulation and have high performance computing resources on-site. They are expanding into frontier areas, including fields such as quantum information and quantum networks.

We invite outstanding young researchers to participate in this excitement as ARL Distinguished Postdoctoral Fellows. These Fellows will display extraordinary ability in scientific research and show clear promise of becoming outstanding future leaders. Candidates are expected to have already successfully tackled a major scientific or engineering problem or to have provided a new approach or insight evidenced by a recognized impact in their field. ARL offers these named Fellowships in honor of distinguished researchers and work that has been performed at Army labs.

The ARL Distinguished Postdoctoral Fellowships are three-year appointments. The annual stipend is $100,000, and the fellowship includes benefits and potential additional funding for selected proposals. Applicants must hold a Ph.D., awarded within the past three years, at the time of application. For complete application instructions and more information, visit: http://sites.nationalacademies.org/PGA/Fellowships/ARL.

Applications must be received by July 1, 2016.



Postcards from the Field

Hi, Everyone.

The middle of March is not a typical time to go out on a Pacific Northwest research cruise, but currently I'm aboard the R/V *Oceanus* with scientists from Oregon State University. They're sampling the water off the Oregon coast to find out how flooding of small rivers influences ocean productivity during the winter, a time normally thought to be unproductive. We got off to a rough start because of winter storms but then got some great weather—and scenery—for our final instrument deployments.

Read more about our cruise at http://bit.ly/PFTF_bompey.

Happy sailing!

Nanci Bompey, AGU public information manager

View more postcards at *http://americangeophysicalunion.tumblr.com/tagged/postcards-from-the-field*.

SHARING SCIENCE

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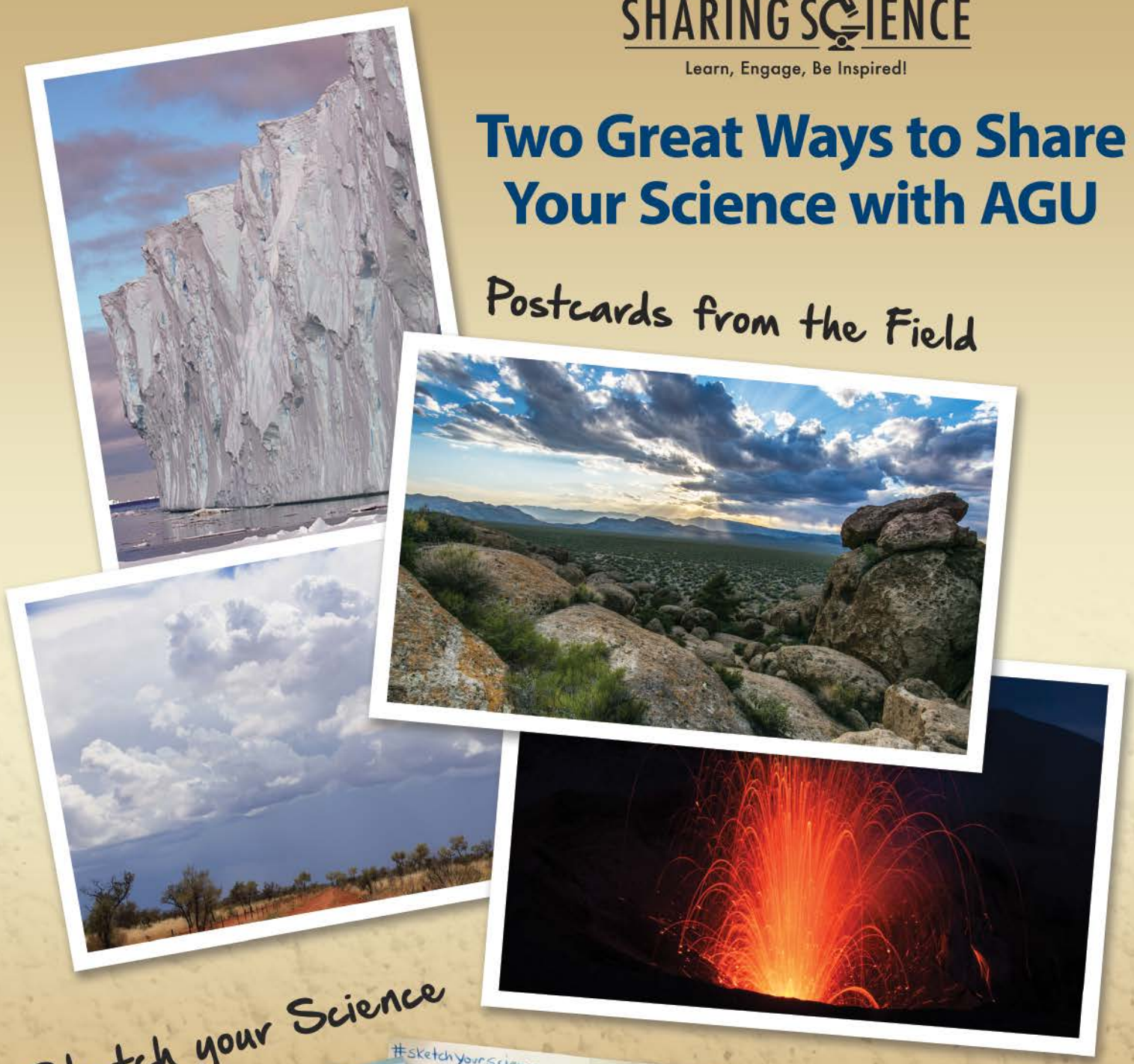
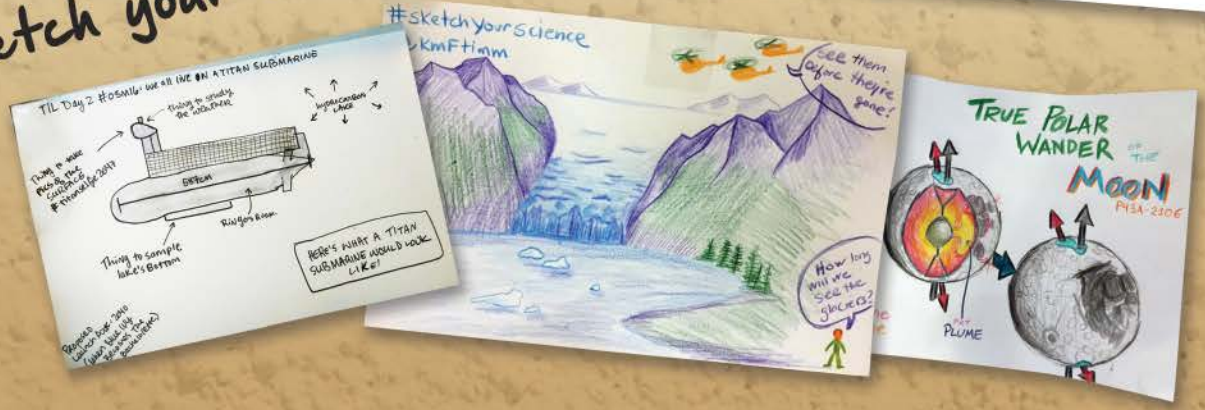
Postcards from the Field



Sketch your Science



View postcards and sketches as well as submission guidelines at

americangeophysicalunion.tumblr.com

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